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Long working hours and burnout in health care workers: non-linear dose-response relationship and the effect mediated by sleeping hours—A cross-sectional study

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ABSTRACT AND KEYWORDS

Objectives: Burnout among health care workers is highly prevalent and has profound impact on quality of care. Hospital on-duty schedules lead to long working hours and short sleeping hours; both are common factors associated with burnout. We examined the dose-response relationship and the potential mediating role of sleeping hours on the association between working hours and burnout among health care workers.

Methods: We collected data on the burnout status, using the Mandarin version of the Copenhagen Burnout Inventory (subscales measure work-related and personal burnouts), working hours, sleeping hours, and relevant measures for 2081 health care personnel who underwent a routine health examination in a medical center in Taiwan during 2016–2017. Four subgroups were compared: physicians (n = 369), nurses (n = 973), technicians (n = 391), and administrators (n = 348).

Results: Average weekly working hours are associated with burnout scores in a non-linear dose-response manner. Compared with a work week of 40 hours, the odds ratio of work-related burnout doubled when hours exceeded 60, tripled when hours exceeded 74, and quadrupled when hours exceeded 84. Physicians' burnout is less susceptible to incremental increases in working hours, compared to the situations in other health care workers. The proportions eliminated by reducing sleeping hours were 25%–73% for physicians and 7%–29% for nurses, respectively.

Conclusions: Our findings suggest that working hours are associated with burnout, and the association was partially mediated by sleeping hours.

Keywords: Burnout; Working hours; Sleeping hours; Health care workers; Mediation analysis

1. INTRODUCTION

Burnout among health care workers was first reported in the United States in 1974,[1] nearly a half-century ago. Since then, the condition has become prevalent worldwide, with reported aggregate prevalence of 44% in medical students,[2] 51% in residents,[3] 80% in physicians,[4] and 15%–60% in nurses.[5] Burnout is characterized by feelings of emotional exhaustion, depersonalization, and reduced personal accomplishment.[6] It not only affects health care workers' personal health[7] but also is associated with perceived competence, medical performance, and medical errors.[8, 9] Increasing concern over burnout among health care workers has led to new attention to policies and solutions for burnout prevention—that is, to eliminate causes of burnout.[10, 11] Epidemiological studies contribute to identifying several predictive factors of burnout, such as female sex, low reported job satisfaction, and long working hours,[12] and offering solution options to prevention strategies. Among predictive factors of burnout across the literature, working hours can be measured and controlled more objectively.

Burnout caused by long working hours among health care workers has commanded considerable attention in recent years,[11, 13] especially policies to restrict long working hours. For example, the United States implemented a limit of up to 80 hours per week for medical residents in 2011.[14] A cohort study of internal medicine resident physicians at 3 academic institutions indicated the proportion of working hours > 70 per week decreased by 5% after 2011 and burnout prevalence and incidence decreased by 8%–13%, although these changes didn't reach statistical significance.[15] The policy was stricter in Europe; for example, the German policy, following the European Working Time Directive, limited hospital physicians' working hours at a limit of up to 48 hours per week.[16] A follow-up of 328 physicians in Hamburg indicated a significant decrease in weekly working hours by 4.5, but the rate of burnout was higher. These inconsistent results trigger our first research question: whether

the shape of the dose-response relationship differs among health care workers who work 80 hours or less per week? To answer this question, we should depict a dose-response relationship between working hours and burnout, and examine whether they are linear or non-linear. A study that includes a group of health care workers whose hours of work range at least from 48 to 80 or more could supply this information.

However, reducing working hours might be a challenge during the COVID-19 pandemic when health care workers are struggling with long working hours.[17, 18] Therefore, the identification of other modifiable risk factors of burnout and the development of effective intervention strategies for managing and mitigating population vulnerabilities to burnout are crucial. Multiple pathways linking the long working hours to burnout, such as sleep deprivation,[19] may also contribute to explain the inconsistency. Long working hours imply that people are spending more time at work, and, thus, when hours of work increase, hours available for sleep may be reduced.[20] It has been well-documented that people who sleep less than 6 hours per day are at higher risk of developing clinically defined burnout.[21] The main purpose of sleep is for the body to restore energy and autonomic response function.[22, 23] The mechanism linking sleep deprivation and burnout includes the increased activity of 2 neuroendocrine stress systems—the autonomic sympathoadrenal system and the hypothalamic-pituitary-adrenal axis.[24] Although workers' burnout differs between working hours, sleeping hours (a predictor of burnout) of workers with different working hours may be also different. Thus, we assumed that there were conditional relationships between working hours and burnout in different sleeping hours. While sleep duration and sleep quality have been recognized as a mediator to explain the association between job stress, sleep problems, and burnout in non-health care workers,[25, 26] previous studies of health care workers treated working hours and sleeping hours as independent variables when estimating their association with burnout.[27, 28] The lack of considering the potential role of sleeping hours as a mediator among the association

109 triggers our second research question: what is the proportion of the effect of working hours
110 on burnout mediated through sleeping hours?
111
112 While most aforementioned studies reported burnout situations for physicians and nurses, a
113 Taiwanese study compared burnout levels of physicians and nurses with those of other
114 medical professions, such as medical technicians and administrative staff.[29] Nurses had the
115 highest prevalence of personal and work-related burnout (66%–73%), while the prevalence
116 of burnout among physicians, medical technicians, and administrative staff was unexpectedly
117 similar—ranging from 32% to 46%.[29] During the COVID-19 pandemic, all levels of health care
118 workers, especially administrative staff, reported high levels of burnout.[30] These results
119 triggered our interest in answering the above two research questions for not only physicians
120 and nurses but also medical technicians and administrators.
121
122 We hypothesize that jobs characterized by long working hours (e.g., physicians) best fit this
123 theory of sleep deprivation. Thus, the objectives of our study were to depict the
124 dose-response relationship between working hours and burnout, estimate the proportion of
125 working hour-related burnout that could be eliminated by resolving insufficient sleeping
126 hours through a hypothetical intervention, and compare differences among physicians,
127 nurses, and other health care workers within the same health care center.
128

129 ## 2. MATERIALS AND METHODS

130 ### 2.1 Study design and setting

131 According to the Regulations of Labor insurance Health Examination of Taiwan, employees
132 are subject to compliance with health examination in the following frequency: once every five
133 years for people aged < 40, once every three years for people aged ≥ 40 to <65, and once per
134 year for those aged 65 or older. The China Medical University Hospital (CMUH), a medical

center located in central Taiwan, provided its workers more frequent health examinations than the regulation—i.e., every year. Health care workers who complete personal health examinations at CMUH are asked to complete a self-administrated questionnaire that includes questions about working hours, sleeping hours, and burnout. They may complete the questionnaire before, at or after their examination. Figure 1 shows the design of our cross-sectional study and our timeline for data collection from each participant and how variables were analyzed in the mediation analysis.

2.2 Study period and participants

Figure 2 outlines participant recruitment, eligibility, and classification. Our main study groups of interest are physicians, nurses, and technicians. However, the workplace context of these studied group may not have to be similar to other health care workers outside this medical center or even to the general public. A reference group can help us understand the norm with a specific context. We can rely on the reference group to understand the norm of the association between working hours and burnout in the medical center. A group within the medical center more similar to the general public is the administrators. Thus, health care workers of this study included physicians, nurses, technicians, and administrators.

2.3 Variables

In the questionnaire, working hours are measured in 2 dimensions: (1) average number of weekly working hours during the 1 month prior to the date of health examination, and (2) average number of weekly working hours during the 6 months prior to the date of health examination. Sleeping hours are defined as the average number of daily sleeping hours on workdays during the aforementioned 2 time periods, i.e., during the 1 month and 6 months prior to the date of health examination. Both working hours and sleeping hours were self-reported using open-ended questions. The short-term and long-term measurements of

both working hours and sleeping hours could be used to assess consistency and reduce potential recall bias. Alcohol and smoking data were also obtained from the questionnaire with four answer options—namely "never," "sometimes," "always," and "former." In our statistical analysis, we treated alcohol and smoking as a binary variable by combining "never" and "former" into a group and combining "sometimes" and "always" in another group.

The questionnaire also measures burnout using the Mandarin version of the Copenhagen Burnout Inventory, which consists of 2 subscales that assess work-related burnout (7 items; e.g., Is your work emotionally exhausting?) and personal burnout (6 items; e.g., How often do you feel tired?) and has been validated.[31, 32] Each question was based on a 5-point scale that ranged from 0 (never/almost never) to 25 (seldom), 50 (sometimes), 75 (often), and 100 (always). We calculated the average scores of the 7 items for work-related burnout and the average scores of the 6 items for personal burnout. Participants who completed fewer than 4 questions regarding work-related burnout or fewer than 3 questions regarding personal burnout were classified as nonresponders. Based on these scores, work-related burnout status was defined as high (average score ≥ 60), moderate (average score 46-59), or low (average score ≤ 45). Similarly, personal burnout status was defined as high (average score ≥ 70), moderate (average score 51–69), or low (average score ≤ 50).[33] In our statistical analysis, we treated each type of burnout as a dichotomous variable. Subjects with work-related burnout scored > 45 were classified as the high-risk group and scores ≤ 45 as the low-risk group. A similar dichotomous classification was applied to personal burnout with a cut-off point at 50, i.e., > 50 as the high-risk group and ≤ 50 as the low-risk group.

2.4 Data management, bias, and study size

A total of 3826 health care workers at the medical center who completed a health examination between January 1, 2016, and December 31, 2017, and also consented their data

to be recorded on the hospital's Clinical Research Data Repository, were considered eligible participants. Since burnout score was the outcome indicator of interest, we collected data on burnout scores from questionnaires completed during the month of a participant's examination or up to 6 months after the examination (fig 1A). We excluded 1121 participants who didn't complete their questionnaire during that time period and thus lacked burnout scores. Among the 2705 participants with complete burnout scores, we collected the reported number of working hours and sleeping hours. We further excluded 624 participants who did not report job titles from the statistical analysis. The final study population for the statistical analysis comprised 2081 participants. For the subgroup analysis, we further classified participants into 4 groups based on their job titles: physicians (including residents), nurses, technicians (including pharmacists), and administrators (including researchers).

2.5 Quantitative variables and statistical methods

Continuous variables were expressed as mean with standard deviation (SD) and median with interquartile range (IQR), and categorical variables were expressed as frequency (percentage). To test between-group differences, we used the nonparametric Kruskal-Wallis test and the chi-square test for continuous and categorical variables respectively. We treated burnout as continuous and categorical (high, moderate, and low) variables and used linear regression models and logistic regression models, respectively, to examine the associations between working hours, sleeping hours, and burnout. We also applied the restricted cubic spline model with three knots located at the 10th, 50th, and 90th percentiles of the overall distribution for working hours to detect the possible dose-response relationship between working hours and burnout. All models were adjusted for age, sex, body mass index, cigarette smoking, alcohol consumption, hypertension, and diabetes.

For the mediation analysis, we applied the method proposed by Lange et al. to assess the effect mediated by sleeping hours in the potential causal pathway between working hours and burnout.[34] Lange et al.'s method relies on a counterfactual framework approximated by inverse probability weighting and provides estimates of both the direct effects of working hours on burnout and the indirect effects of sleeping hours, as depicted in Figure 1B. We performed Lange's method based on the logistic regression due to our outcome was a binary variable. Moreover, due to we did not observe the significant interaction between the association of the exposure and the mediator on the outcome (p-value >0.05), all direct effects are equal (i.e., control direct effect vs. natural direct effect).[35] The causal interpretations in the mediation analysis are valid if the following assumptions are met: (1) there are no unmeasured confounders in the causal pathways between sleeping hours and burnout, between working hours and sleeping hours, and between working hours and burnout; (2) there is no confounder in the pathway between sleeping hours and burnout that is affected by working hours.

We applied aforementioned analyses to overall participants and also to each subgroup to investigate whether the main result remain robust. All statistical analyses were performed in SAS version 9.4 (SAS Institute, Cary, NC, USA), and R version 3.2.3 (R Foundation for Statistical Computing, Vienna, Austria). The statistical significance level was set at α =.05 based on a 2-sided test.

3. RESULTS

The mean age of all participants (N = 2081) was 39.9 years; 73.7% were female and 26.3% were male (Table 1). On average, the participants had been at their current job title for 7 years. Across all participants, average weekly working hours were 46.9 hours over the past 1 month and 47.1 hours over the past 6 months. Average daily sleeping hours on workdays was

6.7 hours. The prevalence of moderate and high levels of work-related burnout was 41.5%, while the prevalence of moderate and high levels of personal burnout was 25.3%. The percentage of high burnout was higher in people who worked ≥ 60 hours per week, followed by those working 41–59 hours and ≤ 40 hours (Appendix Table S1).

We observed significantly increased odds ratio (OR) estimates of burnout when the average number of weekly working hours in the past 1 month exceeded 40 hours (black lines in fig 3; Appendix Figure S1 shows each dose-response curve with 95% confidence interval), with a nonlinear dose-response relationship between working hours and OR of burnout. For work-related burnout, the ORs doubled when average working hours exceeded 59 hours over 1 month (fig 3A) or 61 hours over 6 months (fig 3B), tripled when hours exceeded 73 or 75 hours, and quadrupled when hours exceeded 84 hours. For personal burnout (fig 3C and 3D), the ORs doubled when working hours exceeded 59 hours over 1 month (fig 3C) or 71 hours over 6 months (fig 3D), tripled when hours exceeded 76 or 86 hours, and quadrupled when hours exceeded 88 or 96 hours. In general, the change in ORs with an increase in average working hours was faster for short-term averages of working hours compared to long-term averages, as well as faster for work-related burnout compared to personal burnout.

The number of working hours was found to be positively associated with work-related and personal burnout, but also negatively associated with average number of sleeping hours (Appendix Table S2). By regressing both working hours and sleeping hours on burnout, we found that average sleeping hours is also significantly associated with burnout; however, the parameter estimates for the association between working hours and burnout is then reduced (Appendix Table S3). Our mediation analysis indicates that the proportion of working-hour-related burnout (12% to 28%) could be eliminated if sleeping hours reached six hours or more among health workers (Table 2).

3.1 Subgroup analysis

After classifying participants based on job titles and excluding those who did not provide job titles, 2081 participants were included in the subgroup analysis. The majority were nurses (46.8%), and the remaining proportion was broadly balanced between physicians (17.7%), technicians (18.8%), and administrators (16.7%; fig 2). The mean ages were 31.0 years for nurses, 35.0 years for technicians, 37.3 years for physicians, and 37.4 years for administrators (Table 1). The subgroup of physicians had 70.7% males; the other subgroups had much higher proportions of females than males (nurses: 4.5% male; technicians, 31.7% male; and administrators: 34.2% male). Participants' average years of experience at their current job were, from low to high, 6.1 years for nurses, 7.0 years for physicians, 7.9 years for technicians, and 8.4 years for administrators.

Average weekly working hours over the past 1 month and 6 months were about 20 to 22 hours higher among physicians (64.2 and 64.6 hours) compared to the other groups (42.4 to 43.7 hours average across groups and time periods). Average daily sleeping hours on workdays were slightly lower among physicians (6.2 hours) compared to the other groups (6.7 to 6.8 hours). Nurses had the highest prevalence of both work-related burnout (50.4%) and personal burnout (30.3%), followed by physicians (37.4% work-related, 28.2% personal), technicians (32.5% work-related, 18.4% personal), and administrators (31.0% work-related, 15.8% personal).

Consistent dose-response relationships between working hours and OR of burnout were observed among physicians (pink lines in fig 3), nurses (green lines in fig 3), and administrators (yellow lines in fig 3), except for technicians. After confirming that working hours were significantly associated with burnout and for the number of sleeping hours for

291 aforementioned 3 groups (Appendix Table S4), we also found sleeping hours to be a
292 significant mediator for the relationship between working hours and burnout among
293 physicians and nurses (Table 2). The estimated proportions of the total association of
294 working hours with burnout that could be reduced by resolving insufficient sleeping hours
295 were 25.3% to 73.3% and 7.1% to 28.8% for physicians and nurses, respectively.
296

297 ## 4. DISCUSSION

298 Our findings show clear dose-response relationships between short-term and long-term
299 working hours and work-related burnout among health care workers. Using 40 working
300 hours per week as a reference level, health care workers who worked approximately 60 hours
301 or more per week had a higher OR of work-related burnout by 2-fold. The OR increased to 3
302 times with average workweeks of 73 hours or more, and increased to 4 times when working
303 hours exceeded 84 hours per week. Long working hours were also associated with personal
304 burnout, although to a milder degree. Among the above relationships, the increase in sleeping
305 hours explains 7% to 73% of the reduction in working hour-related burnout in physicians and
306 nurses. Our subgroup analysis indicates that compared with other groups, physicians'
307 burnout is less susceptible to incremental increases in working hours but more likely to be
308 mediated by sleeping hours.
309

310 The nonlinear relationship between working hours and burnout, measured for averages of 40
311 to 120 working hours per week, indicated that ORs of burnout increased faster when working
312 hours were already high, and particularly when the weekly average exceeded 80 hours.
313 Supposing that average weekly working hours could be reduced from 80 hours to 70 hours
314 among all health care workers, we could expect the OR of burnout to be reduced by about
315 25% (from OR $\approx$ 3.6–3.7 to OR $\approx$ 2.7-2.8). A reduction from 80 hours to 60 hours per

316 week could halve the OR, from OR ≈ 3.6-3.7 to OR ≈ 2.0-2.1. Therefore, any level of
317 reduction of average working hours may help protect health care workers from burnout.
318
319 Setting up action levels at which to take preventive measures and caps for working hours is
320 important, too. By taking the minimum levels of working hours that showed significant OR
321 (see fig 3), we can suggest action levels at which to take preventive measures: 46 hours for
322 nurses; 48 hours for administrators; and 86 hours for physicians. Supposing that an OR of 4
323 (by rounding OR of burnout when average weekly working hours reached 80 hours for all
324 participants) were determined to be an unacceptable level, we can suggest a cap of working
325 hours at 70 hours for nurses; 56 hours for administrators; and 94 hours for physicians.
326
327 The rationale for collecting 2 dimensions of average weekly working hours—the average of
328 the past 1 month and the average of the past 6 months—followed the governmental
329 recognition criteria for overwork-related diseases established in Taiwan.[36] The national
330 governments have officially included the average number of working hours over the past 6
331 months as a key factor for developing overwork-related cardiovascular diseases and listed it
332 as a key criterion in the recognition guidelines for occupational diseases.[36] Our findings show
333 that average working hours over the past 6 months is as important as average hours over the
334 past 1 month in terms of work-related burnout, which is in alignment with the government
335 recognition guidelines. Preventive actions for burnout should consider the preventing long
336 working hours for a long run.
337
338 We also observed differences in the dose-response relationship based on job title. Per-unit
339 (i.e., per-hour) increases in working hours are associated with a higher OR of burnout among
340 administrators, followed by nurses and physicians. Physicians' burnout status is less
341 susceptible to increases or decreases in working hours. Job title can also be a proxy indicator

for job demands and controls. High job demands, low job control, and low workplace support have been recognized as important factors associated with burnout.[37, 38] Although physicians, nurses, and administrators all fall into the area of active jobs,[39] people who are able to spend more time on the activities that are most meaningful to them have reported lower rates of burnout.[40] One survey reported that physicians' most meaningful work consisted of patient care (68%), followed by research (19%), education (9%), and administration (3%).[40] This could help explain our findings that physicians are less susceptible to burnout at high levels of working hours, if they are doing direct patient care.

We've estimated that the proportion of the effect of working hours on burnout that could be eliminated by intervening on sleeping hours was 25% to 73% in physicians and 7% to 29% in nurses. One previous study of Taiwanese nurses also documented sleeping hours and burnout in a dose-response manner.[41] Another study from Taiwan indicated that weekend catch-up sleep was associated with lower burnout status in health care workers who slept less than 7 hours on workdays.[29] One previous study reported that working more than 55 hours a week was associated with sleep disturbance, such as shortened sleeping hours or difficulty falling asleep, compared with working 35 to 40 hours a week.[20] Our findings add to existing knowledge by testing the hypothesis that interventions to ameliorate sleeping hours is more apparent in jobs characterized by longer working hours (physicians: 64 hours per week; other groups: <45 hours per week). This may be because extremely long working hours directly reduce the time available for sleep. For those groups working long hours but fewer hours than physicians, sleeping hours accounted for less of the indirect effect on burnout. In these cases, it might be the working hours themselves that contributed to burnout. Longer working hours represent longer exposure time to work-related factors associated with burnout, such as job stress. Our findings thus suggest the following recommendations for preventing burnout

among health care workers: (1) promote sufficient sleep duration for those working longer hours, and (2) reduce working hours as the ultimate solution.

4.1 Limitations

There are several limitations to this study we should address. First, this is a cross-sectional study, which limits our ability to make causal inferences. There are cumulative risk factors that may cause burnout, and this warrants longitudinal data collection on potential causes and a time-series analysis. High levels of burnout may also be the risk factors of sleep problem.[23] The bi-directional effect between sleeping hours and burnout necessities a cohort to examine longitudinal changes. This kind of longitudinal study may also contribute to estimating burnout-associated costs and turnovers across different job titles as well as bi-directional effect between sleeping hours and burnout.[23, 42, 43] Second, the study setting is a medical center in central Taiwan. This medical center runs multiple departments, such as internal medicine, surgery, children's hospital, obstetrics and gynecology, Chinese medicine, and international medicine. The number of health care professionals in this medical center accounts for about 8% of the total registered health care professionals of all medical centers in Taiwan. Recruiting participants from a single hospital meant we could avoid organization-level variance in burnout or factors associated burnout,[44] but may limit the generalizability of findings to health care workers outside this one health care management system. A third limitation is posed by the several potential factors associated burnout that were not measured by our study. For example, experience of mistreatment (e.g., discrimination, harassment, and abuse) is associated with the degree of burnout and has been reported to be 2 to 3 times higher among women than men.[45] For the purposes of this study, we assumed that exposure to such factors would be in proportion to hours spent at work, and thus that working hours would act as a variable relevant to these unmeasured variables. A separate analysis incorporating prior known factors related to burnout, such as shift-work

schedules, sleep interruptions, and sleep quality,[46, 47] may contribute to explore the pathway between working hours, sleeping hours, and burnout.

5. CONCLUSIONS

Our findings showed significant positive associations between working hours and burnout among health care workers and potential interventions to increase sleeping hours could reduce the risk of burnout attributable to working hours. The current shortage of health care professionals, especially frontline health care workers amid the COVID-19 pandemic,[30] means that reducing working hours might be a challenge in the short term. Several intervention strategies, including strengthening the awareness that health care workers need basic healthy lifestyles, have been recommended to support their mental health.[48] Our findings support the suggestion of alternative way to prevent burnout among physicians—promoting sufficient sleep.

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DISCLOSURE

- **Ethical approval:** This study was approved by the Big Data Center and the Research Ethical Committee/Institutional Review Board of China Medical University Hospital (CMUH105-REC3-068, CMUH108-REC2-022).

- **Informed consent:** All participants who completed personal health examinations, based on the Regulations of Labor insurance Health Examination of Taiwan, were informed and could decide whether their data to be recorded on the hospital's Clinical Research Data Repository. Only consented data were analyzed in this study.
- **Registry and the Registration No. of the study/Trial:** N/A.
- **Animal Studies:** N/A.
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AUTHOR CONTRIBUTIONS

R.T.L. contributed to idea formulation, data interpretation, and writing of the manuscript. Y.T.L. contributed to data analysis, reporting results, and data interpretation. Y.F.H. contributed to data collection and data analysis. C.C.K. contributed to data collection and data interpretation. All authors participated in commenting on subsequent drafts, approved the final manuscript, and agreed to submit for publication. R.T.L. and Y.T.L. are the guarantors. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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FIGURE LEGENDS

Figure 1. Timeline and Conceptual Diagram

Figure 2. Participant Recruitment, Eligibility, and Classification

Figure 3. Dose-Response Relationships Between Working Hours and Odds Ratios of Burnout

584 **TABLES**

585 **Table 1. Participant Characteristics**

Characteristics	All participants (N = 2081)	Participant groups			
		Physicians (n = 369)	Nurses (n = 973)	Technicians (n = 391)	Administrators (n = 348)
Age in years					
Mean (SD)	39.9 (8.9)	37.3 (9.7)	31.0 (7.5)	35.0 (8.8)	37.4 (9.0)
Median (IQR)	32.3 (26.8, 38.9)	34.5 (29.8, 41.1)	29.2 (24.9, 35.9)	32.9 (27.9, 40.7)	37.6 (29.9, 43.0)
Sex					
Male, number (%)	548 (26.3)	261 (70.7)	44 (4.5)	124 (31.7)	119 (34.2)
Female, number (%)	1533 (73.7)	108 (29.3)	929 (95.5)	267 (68.3)	229 (65.8)
Smokes cigarettes					
Number (%)	53 (2.6)	3 (0.8)	16 (1.6)	15 (3.8)	19 (5.5)
Drinks alcohol					
Number (%)	703 (33.8)	184 (49.9)	255 (26.2)	140 (35.8)	124 (35.6)
Body mass index					
Mean (SD)	23.3 (4.3)	24.6 (4.0)	22.7 (4.5)	23.2 (4.0)	23.9 (4.2)
Median (IQR)	22.6 (20.1, 25.7)	24.3 (21.6, 26.7)	21.6 (19.5, 24.8)	22.5 (20.3, 25.2)	23.3 (20.6, 26.3)
Hypertension					
Number (%)	92 (4.4)	29 (7.9)	23 (2.4)	15 (3.8)	25 (7.2)
Diabetes mellitus					
Number (%)	33 (1.6)	10 (2.7)	4 (0.4)	7 (1.8)	12 (3.5)
Years in current job title					
Mean (SD)	7.0 (7.2)	7.0 (7.4)	6.1 (6.5)	7.9 (7.9)	8.4 (7.8)
Median (IQR)	4.0 (1.4, 10.6)	4.1 (1.4, 10.0)	3.6 (1.3, 9.5)	4.7 (1.3, 12.5)	6.4 (1.6, 13.0)
Average weekly working hours, past 1 month					
Mean (SD)	46.9 (13.7)	64.2 (20.8)	43.6 (8.0)	42.6 (6.2)	42.7 (7.9)
Median (IQR)	44 (40, 48)	60 (48, 80)	40 (40, 48)	40 (40, 45)	40 (40, 45)
Average weekly working hours, past 6 months					
Mean (SD)	47.1 (13.7)	64.6 (20.3)	43.7 (8.0)	42.4 (6.9)	42.9 (7.6)
Median (IQR)	44 (40, 50)	60 (48, 80)	42 (40, 48)	40 (40, 45)	40 (40, 45)
Average daily sleeping hours, workdays					
Mean (SD)	6.7 (1.0)	6.2 (0.9)	6.8 (1.1)	6.7 (0.9)	6.7 (1.0)
Median (IQR)	7 (6, 7)	6 (6, 7)	7 (6, 7)	7 (6, 7)	7 (6, 7)
Burnout, work-related					
Score, mean (SD)	43.4 (12.5)	43.4 (13.6)	45.3 (13.0)	41.2 (9.9)	40.7 (11.4)
Score, median (IQR)	42.9 (35.7, 50.0)	39.3 (35.7, 50.0)	46.4 (35.7, 50.0)	39.3 (35.7, 46.4)	39.3 (32.1, 46.4)
Level: low, number (%)	1218 (58.5)	231 (62.6)	483 (49.6)	264 (67.5)	240 (69.0)
Level: moderate, number (%)	670 (32.2)	99 (26.8)	377 (38.8)	105 (26.9)	89 (25.6)
Level: high, number (%)	193 (9.3)	39 (10.6)	113 (11.6)	22 (5.6)	19 (5.4)
Burnout, personal					
Score, mean (SD)	44.7 (15.6)	45.1 (16.9)	47.1 (16.0)	41.4 (13.5)	41.2 (14.1)
Score, median (IQR)	41.7 (33.3, 54.2)	41.7 (33.3, 54.2)	45.8 (33.3, 54.2)	37.5 (29.2, 50.0)	37.5 (29.2, 50.0)
Level: low, number (%)	1555 (74.7)	265 (71.8)	678 (69.7)	319 (81.6)	293 (84.2)
Level: moderate, number (%)	352 (16.9)	67 (18.2)	197 (20.2)	54 (13.8)	34 (9.8)
Level: high, number (%)	174 (8.4)	37 (10.0)	98 (10.1)	18 (4.6)	21 (6.0)

586 SD = standard deviation; IQR = interquartile range.

587 **Table 2. Estimated Total and Direct Effects of Working Hours on Burnout and the Effect**
588 **Mediated by Sleeping Hours**

		Odds ratio (95% confidence interval)			Proportion eliminated
		Total effect	Direct effect	Indirect effect	
A. All participants					
Burnout, work-related					
Average weekly working hours, past 1 month	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.50 (1.23, 1.83)	1.44 (1.17, 1.77)	1.02 (1.01, 1.03)	12.0%
	≥60	1.90 (1.28, 2.80)	1.67 (1.11, 2.50)	1.08 (1.03, 1.13)	25.6%
Average weekly working hours, past 6 months	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.42 (1.16, 1.73)	1.37 (1.12, 1.68)	1.02 (1.01, 1.03)	11.9%
	≥60	1.80 (1.22, 2.64)	1.63 (1.10, 2.41)	1.06 (1.02, 1.11)	21.3%
Burnout, personal					
Average weekly working hours, past 1 month	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.52 (1.21, 1.91)	1.42 (1.12, 1.79)	1.03 (1.02, 1.04)	19.2%
	≥60	2.44 (1.61, 3.71)	2.04 (1.30, 3.20)	1.13 (1.07, 1.19)	27.8%
Average weekly working hours, past 6 months	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.44 (1.15, 1.81)	1.37 (1.08, 1.72)	1.03 (1.02, 1.04)	15.9%
	≥60	2.27 (1.51, 3.42)	1.96 (1.27, 3.04)	1.11 (1.06, 1.16)	24.4%
B. Physicians					
Burnout, work-related					
Average weekly working hours, past 1 month	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	0.92 (0.42, 2.02)	0.90 (0.41, 1.97)	0.99 (0.97, 1.00)	NA
	≥60	1.24 (0.59, 2.58)	1.09 (0.53, 2.23)	1.10 (1.01, 1.20)	62.5%
Average weekly working hours, past 6 months	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.15 (0.51, 2.60)	1.04 (0.46, 2.39)	1.01 (1.00, 1.02)	73.3%
	≥60	1.42 (0.66, 3.08)	1.20 (0.55, 2.60)	1.11 (1.01, 1.21)	52.4%
Burnout, personal					
Average weekly working hours, past 1 month	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.42 (0.57, 3.55)	1.39 (0.56, 3.44)	0.98 (0.97, 1.00)	7.1%
	≥60	1.95 (0.83, 4.59)	1.71 (0.73, 4.03)	1.13 (1.03, 1.25)	25.3%
Average weekly working hours, past 6 months	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.27 (0.51, 3.18)	1.09 (0.45, 2.69)	1.02 (1.00, 1.03)	66.7%
	≥60	1.62 (0.68, 3.85)	1.30 (0.55, 3.07)	1.13 (1.02, 1.25)	51.6%
C. Nurses					
Burnout, work-related					
Average weekly working hours, past 1 month	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.40 (1.07, 1.83)	1.36 (1.04, 1.78)	1.02 (1.00, 1.04)	10.0%
	≥60	1.58 (0.73, 3.42)	1.47 (0.67, 3.25)	1.05 (1.01, 1.08)	19.0%
Average weekly working hours, past 6 months	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.26 (0.97, 1.64)	1.24 (0.95, 1.61)	1.02 (1.00, 1.03)	7.7%
	≥60	1.84 (0.90, 3.79)	1.78 (0.86, 3.67)	1.03 (1.00, 1.05)	7.1%
Burnout, personal					
Average weekly working hours, past 1 month	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.51 (1.13, 2.02)	1.44 (1.07, 1.92)	1.03 (1.01, 1.06)	13.7%
	≥60	1.52 (0.68, 3.41)	1.37 (0.58, 3.22)	1.06 (1.02, 1.11)	28.8%
Average weekly working hours, past 6 months	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.34 (1.00, 1.79)	1.30 (0.97, 1.74)	1.02 (1.01, 1.04)	11.8%
	≥60	1.86 (0.91, 3.83)	1.78 (0.85, 3.73)	1.04 (1.01, 1.06)	9.3%

D. Technicians					
Burnout, work-related					
Average weekly working hours, past 1 month	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.33 (0.84, 2.11)	1.30 (0.82, 2.08)	1.00 (0.97, 1.04)	9.1%
	≥60	3.87 (0.63, 23.69)	4.72 (0.59, 37.80)	1.01 (0.92, 1.12)	NA
Average weekly working hours, past 6 months	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.34 (0.85, 2.11)	1.33 (0.84, 2.12)	1.00 (0.95, 1.06)	2.9%
	≥60	3.05 (0.46, 20.40)	3.85 (0.40, 36.81)	1.00 (0.88, 1.14)	NA
Burnout, personal					
Average weekly working hours, past 1 month	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.27 (0.74, 2.19)	1.16 (0.67, 2.01)	1.04 (0.99, 1.10)	40.7%
	≥60	1.91 (0.31, 11.808)	1.87 (0.24, 14.30)	1.14 (0.99, 1.31)	4.4%
Average weekly working hours, past 6 months	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	1.37 (0.80, 2.37)	1.29 (0.73, 2.29)	1.06 (0.98, 1.14)	21.6%
	≥60	3.05 (0.45, 20.68)	3.10 (0.37, 25.92)	1.14 (0.95, 1.36)	NA
E. Administrators					
Burnout, work-related					
Average weekly working hours, past 1 month	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	2.78 (1.68, 4.62)	2.79 (1.68, 4.65)	1.00 (0.96, 1.05)	NA
	≥60	2.78 (0.71, 10.95)	2.88 (0.70, 11.87)	1.00 (0.96, 1.04)	NA
Average weekly working hours, past 6 months	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	2.51 (1.52, 4.14)	2.49 (1.50, 4.14)	1.01 (0.97, 1.04)	1.3%
	≥60	1.45 (0.35, 5.91)	1.44 (0.35, 5.94)	1.01 (0.98, 1.04)	2.2%
Burnout, personal					
Average weekly working hours, past 1 month	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	2.35 (1.23, 4.52)	2.39 (1.25, 4.56)	1.00 (0.94, 1.06)	NA
	≥60	10.31 (2.52, 42.24)	11.02 (2.89, 42.0)	1.00 (0.95, 1.05)	NA
Average weekly working hours, past 6 months	≤40	1.00 (reference)	1.00 (reference)	1.00 (reference)	-
	41-59	2.33 (1.22, 4.45)	2.31 (1.21, 4.41)	1.01 (0.96, 1.06)	1.5%
	≥60	5.42 (1.37, 21.38)	5.40 (1.52, 19.19)	1.01 (0.97, 1.05)	0.5%

Estimates adjusted for age, sex, body mass index, seniority (years) in job, cigarettes, alcohol, job type, hypertension, and diabetes mellitus.

FIGURES

Figure 1. Timeline and Conceptual Diagram

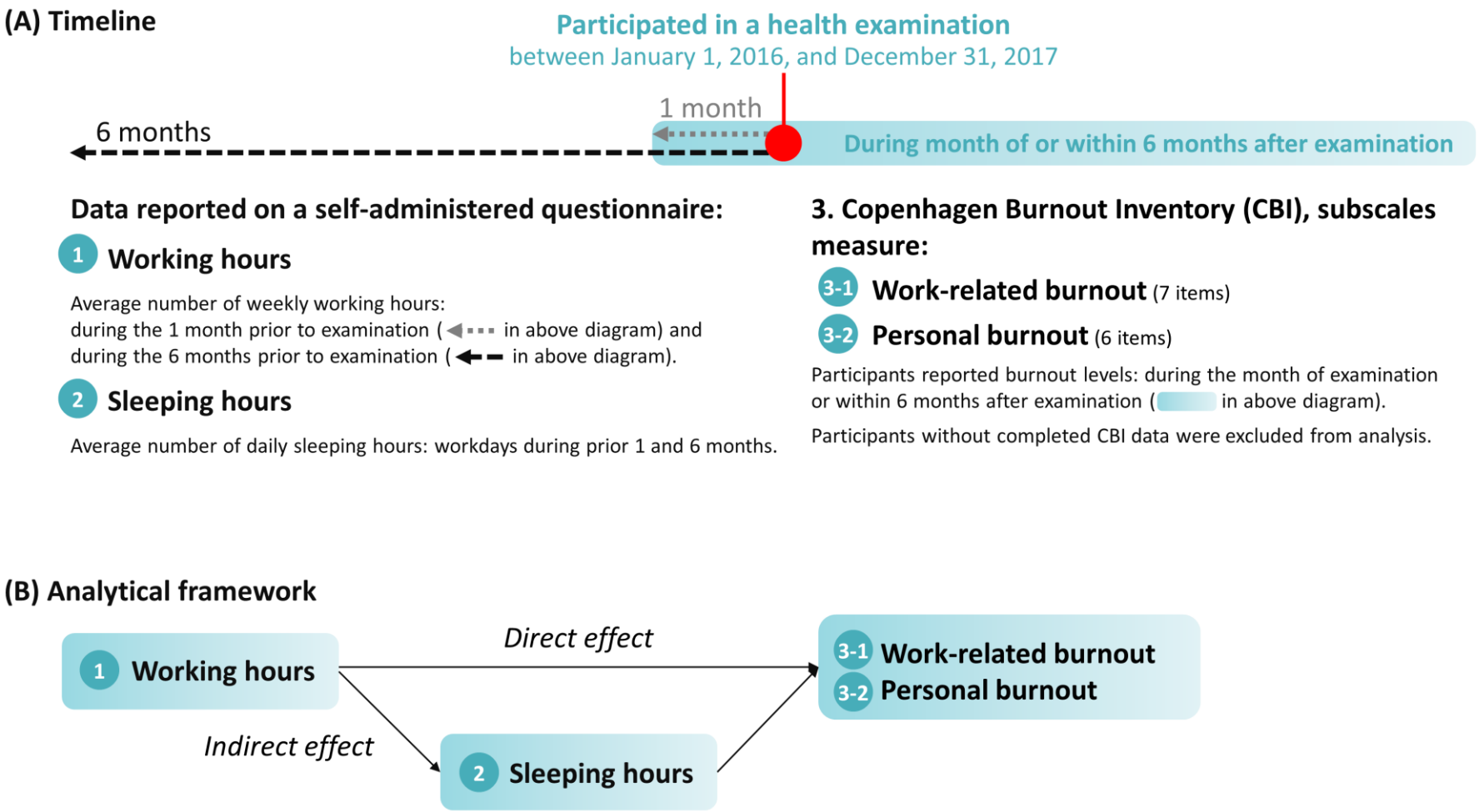


Figure 2. Participant Recruitment, Eligibility, and Classification

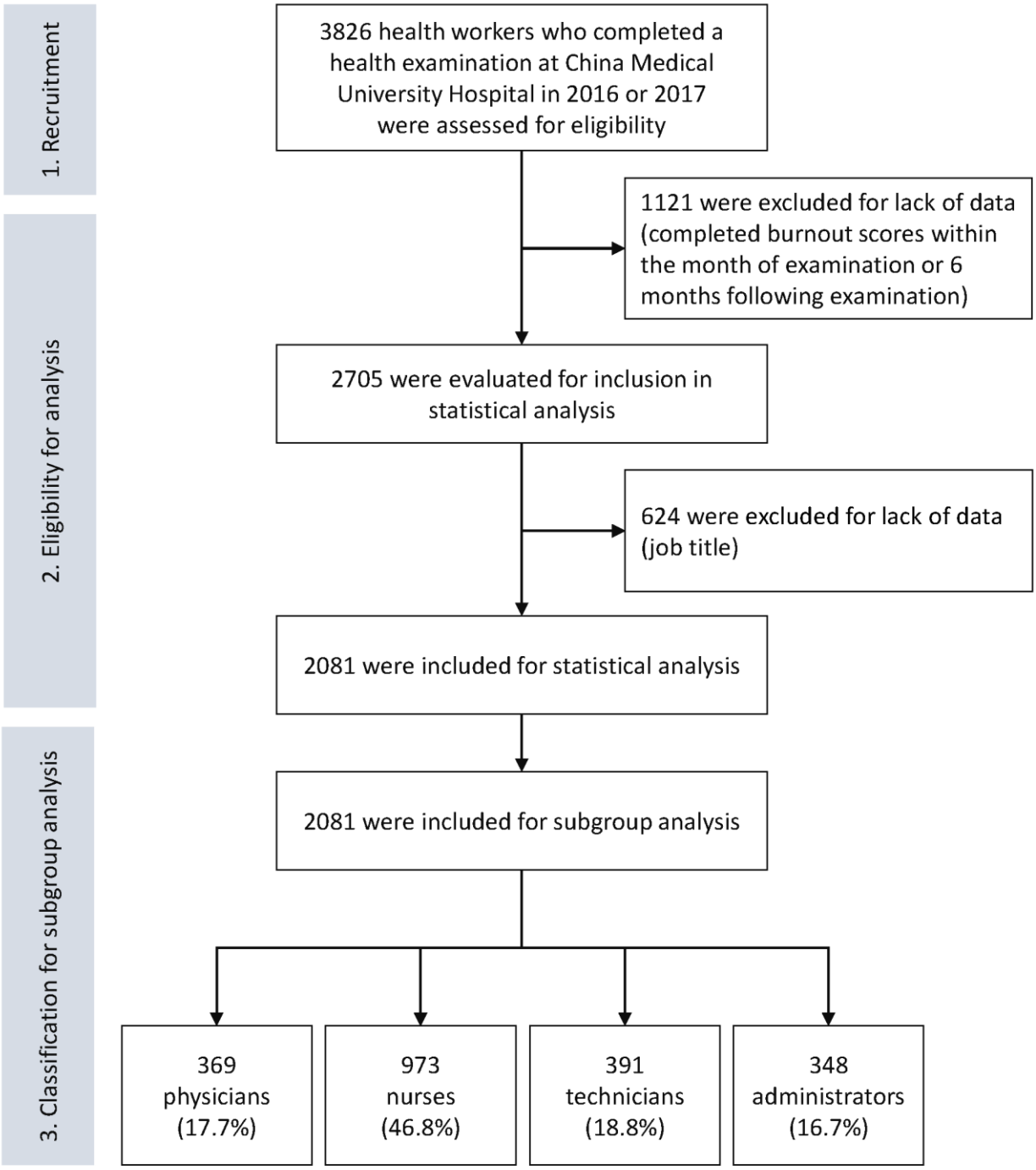
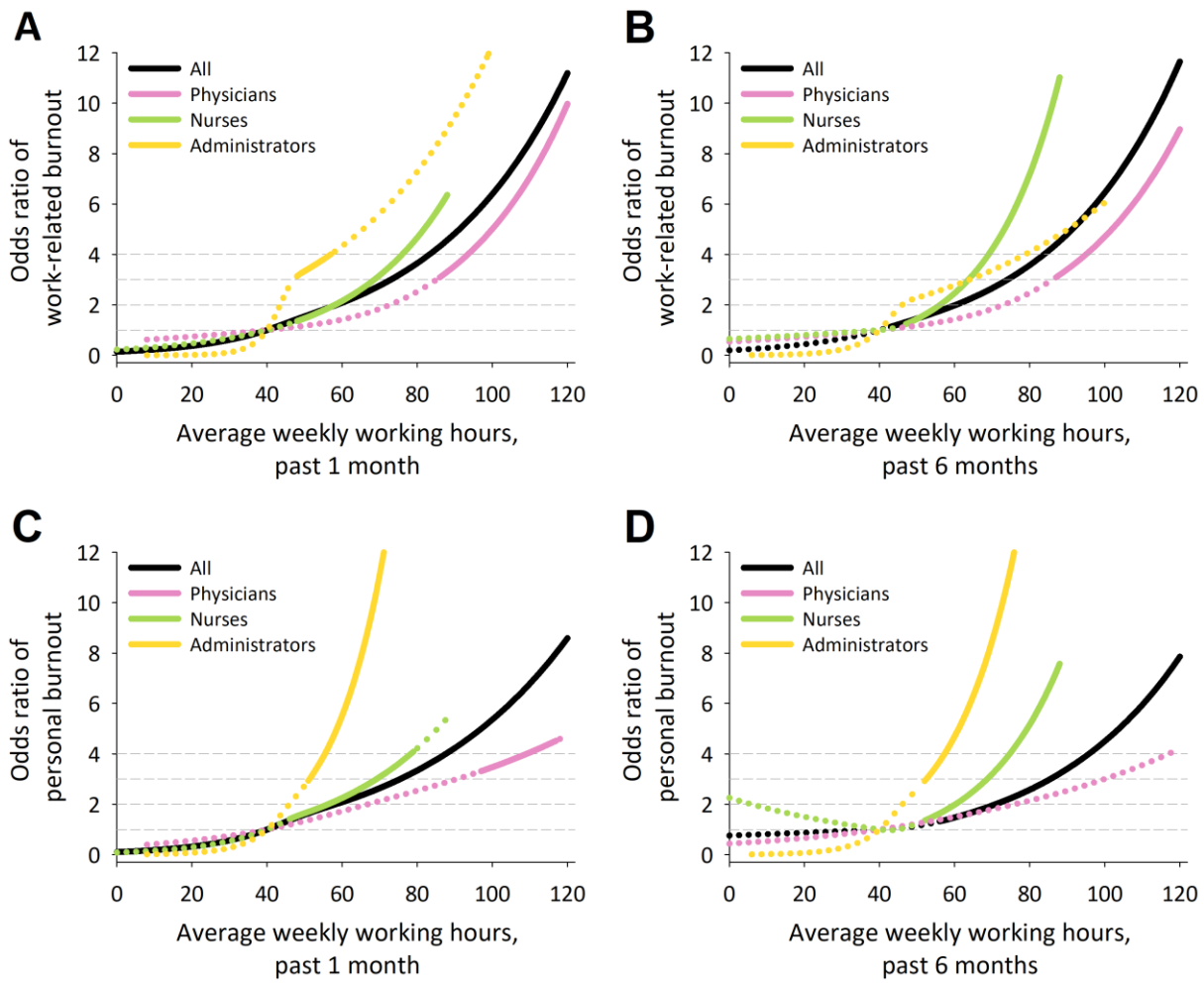


Figure 3. Dose-Response Relationships Between Working Hours and Odds Ratios of Burnout



Solid lines represent odds ratios that reach statistical significance at P < .05. Dotted lines represent odds ratios that do not reach statistical significance.